Phase I Project Summary

Firm: Ophir Corporation
Contract Number: NNX11CG56P
Project Title: Multifunction Lidar for Air Data and Air Hazard Measurement

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

The innovation is providing a single sensor that has dual-use functionality – air data measurement and kinetic air hazard detection in a package that is easily integrated onto commercial aircraft. Conventional air data systems provide critical information to the aircraft for safe flight, but there are vulnerabilities, as evidenced by the recent Air France accident. A more robust air data system for flight controls on aircraft is needed – particularly to measure airspeed in icing and severe weather conditions. This proposed sensor also measures air hazards which impacts the safety of air traffic and smoothness of ride; decreases fuel consumption and incidence of encounters with turbulent events on aircraft. This project successfully demonstrated the viability of providing a single sensor that has multiple use functionality, air data measurement, turbulence and kinetic wind hazard detection, in a light-weight, low cost laser radar (lidar) for use on commercial aircraft. The Phase I effort entailed determination of the system requirements, development of an optimal dual-use sensor, prototype design, calculation of range and accuracy expectations for each of the lidar modes, and a preliminary design of the Phase II prototype. This technology was a TRL 2 at contract initiation and reached TRL 3 by contract close.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

Technical Objectives:

- Complete a thorough requirements analysis for the multifunction lidar in conjunction with commercial aircraft manufacturers such as The Boeing Company.
- Determine optimal lidar system design capable of range-resolved, long range air hazard detection and a dual-use, shorter range air data for enhanced aviation safety.
- Design and evaluate the performance of the Phase II prototype sensor concept.
- Establish a Phase II program test plan, enabling demonstration of the Phase II prototype under desired operational conditions.

Work Plan:

- Task 1: Completed a thorough requirements analysis for the multifunction lidar.
- Task 2: Determined the optimal system design to achieve long-range kinetic wind hazard monitoring and short-range air data monitoring in a single sensor through Trade Study analyses of incoherent laser radar sensor designs.
- Task 3: Designed a preliminary laser radar sensor for a Phase II demonstration.
- Task 4: Estimated the Phase II sensor performance using a lidar signal and noise model.
- Task 5: Established a Phase II program test plan, enabling the Phase II prototype to be demonstrated under the desired operational conditions.
- Task 6: Presented a final report of these research efforts summarizing all research performed.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

This project successfully demonstrated the viability of providing a single sensor that has multiple use functionality, air data measurement and kinetic wind hazard detection, in a light-weight, low cost laser radar (lidar) for use on commercial aircraft.

Several key development steps were established during this period of performance including:

- Determination of a viable scanning pattern and system necessary for 3D airspeed measurements; not a single point or fixed;
- Selection of a laser source based on rugged and inexpensive diode lasers that are small and inexpensive;
- Use of a vibration and temperature insensitive Edge Detection filter compatible with aircraft operational environment;
- Performance modeling that validates the capability of this Rayleigh/Mie lidar to provide turbulence and air data measurements;
- Phase II prototype sensor design supporting a flight test demonstration in Phase II;
- Letters of Support from three Industry sectors for this multifunction lidar.

Through this Phase I effort, a thorough set of sensor requirements were developed in conjunction with commercial users; while optimizing the multifunction lidar design for both the measurement of air data and the determination of turbulence.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

In the NASA organization, key programs that will benefit from this multifunction lidar development include:

- ❒ NextGen Air Transportation Safety Program for operations, and
- ❒ Aviation Safety Program, Atmospheric Environment Safety Technologies.

NASA has directed significant research toward detection and monitoring of hazards to aircraft - Weather Accident Prevention Project, Turbulence Auto-PIREP System and Turbulence Prediction and Warning Systems (TPAWS). However, these systems are not viable in all weather conditions and have a potential time delay in reporting. Adding lidar to the TPAWS would significantly augment the current weather radar.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

The Non-NASA commercial applications for this multifunction lidar include commercial aircraft manufacturers, manned and unmanned military aircraft developers, and manufacturers of conventional air data probes. The regional jet market and the Air Force aircraft developers may also benefit from the air data measurement capability of this lidar for new aircraft flight testing and calibration. The commercial markets have been reticent to adopt an optical air data sensor due to the size, weight and power consumption factors, as well as, the single function nature of the sensor. But, the ability to condense the sensor and offer multimode operation enables the market acceptance and ultimate sensor commercialization.

Name and Address of Principal Investigator: (Name, Organization, Street, City, State, Zip)

Dr. Loren Caldwell, Ophir Corporation, 10184 West Belleview Ave., Suite 200, Littleton, CO 80127-5709

Name and Address of Offeror: (Firm, Street, City, State, Zip)

Ophir Corporation, 10184 West Belleview Ave., Suite 200, Littleton, CO 80127-5709